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A new type of crystal holders for focussing X-ray spectrometers

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With 3 figures in the text

The crystal holders hitherto used in focussing X-ray spectrometers are all in principle of the same type. A plane-parallel crystal plate is pressed against a steel piece, which is ground cylindrical so that the crystal attains the same radius of curvature as the cylinder. In most constructions the pressure is obtained by the crystal plate being placed between two cylindrical steel pieces of the same radius, one of which is concave and the other convex.

If a well bent crystal is to be obtained, the cylindric surfaces must be ground very carefully so that the radius of curvature is the same everywhere. This makes the holders expensive to produce.

We have used another construction in our laboratory with good results. The principles are to be seen in Fig. 1. A plane-parallel crystal plate is placed between the two pairs of steel axes AA and BB, all being parallel to each other. These are pressed in the directions of the arrows. In doing so the crystal plate is bent. Between the two axes AA it is not exposed to any external forces. Hence the same bending moment acts on the plate between these two axes.

Fig. 2 shows a length section of the part of the crystal between axes AA. CD is a cross section of the plate. On this there is a bending moment M acting around axis S on CD. The moment M is shown by a round arrow in the figure. If σ is the normal stress and df a surface element of the cross section, then

$$M = \int \sigma \, df \cdot y.$$

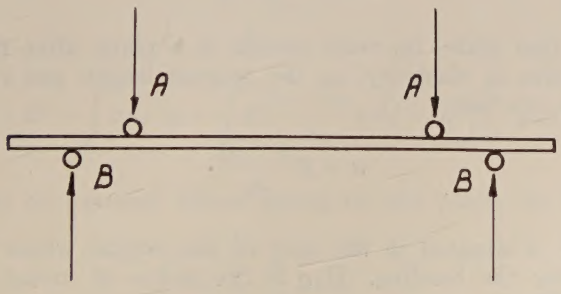

Fig. 1.

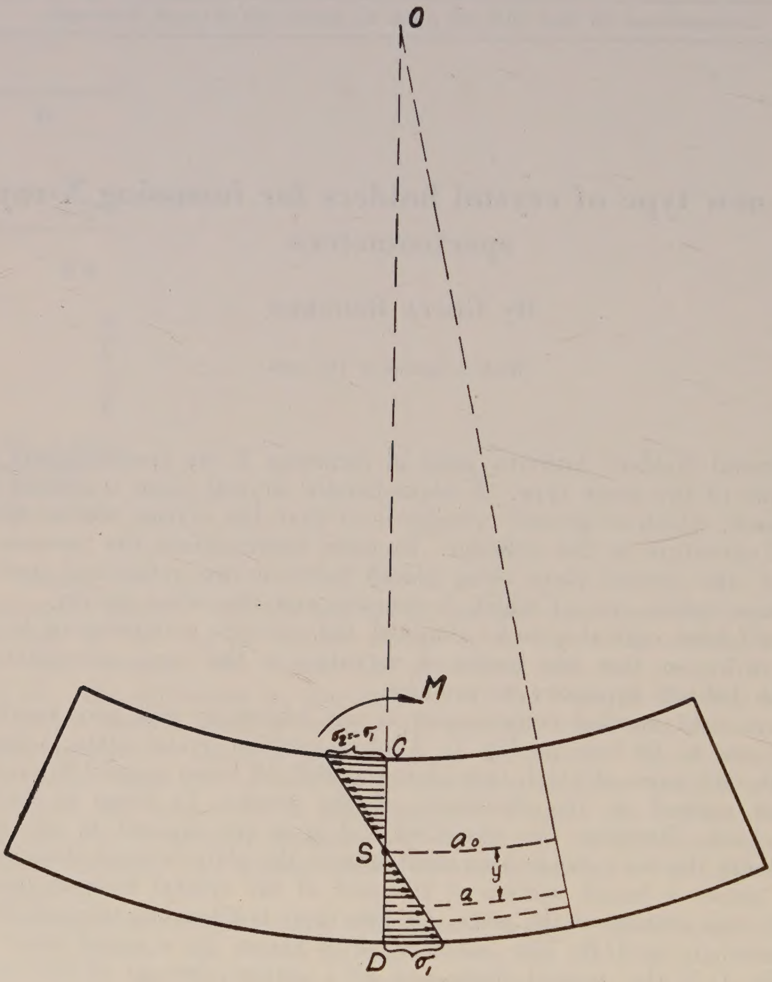

Fig. 2.

If we have a thin plate, its cross section is a plane after the bending, too. If E is the modulus of elasticity, a_0 the original length and a the length when the plate is bent, we get

$$\sigma = E\frac{a - a_0}{a_0}.$$

But the point S is situated in the part of the crystal where the length does not change during the bending. If ϱ is the radius of curvature of this part, we obtain from Fig. 2

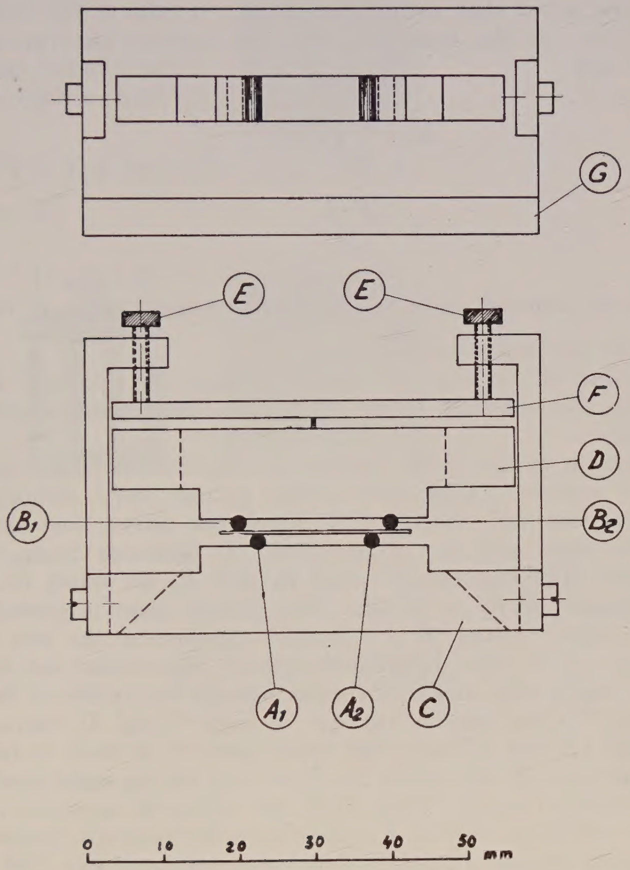

Fig. 3.

$$\frac{\varrho}{\varrho + y} = \frac{a_0}{a}$$

$$\therefore \frac{a - a_0}{a_a} = \frac{y}{\varrho}$$

$$\therefore M = \int \sigma \, d f \cdot y = \int E \cdot \frac{a - a_0}{a_0} \, y \, d f = E \int \frac{y}{\varrho} \cdot y \, d f.$$

Since there are no external forces acting on the plate, we have

$$\int \sigma \, d f = \frac{E}{\varrho} \int y \, d f = 0.$$

Hence the point $y = 0$ that corresponds to $\sigma = 0$ falls in the centre of gravity of the plate, i.e. in the centre of the part between the two axes AA. By integrating we get

$$M = \frac{E}{\varrho}\int y^2\,df = \frac{E \cdot I}{\varrho}$$

$$\therefore \varrho = \frac{E \cdot I}{M},$$

where $I =$ the moment of inertia of the cross section $= \frac{b\,h^3}{12}$ (b the width, and h the height of the cross section).

As the moment of bending is constant between the two axes AA, the radius of curvature is also constant there. Hence the plate must attain the form of an ideal cylinder.

The construction of the holder is seen in Fig. 3. The brass pieces C and D have the two surfaces facing each other ground very smooth. Two small, parallel grooves are cut out of C, in which two silver steel axes A_1 and A_2 are fixed. The steel rods are ground with the diameter 2 mm. The distance $A_1 A_2$ is 15 mm. The two parallel axes B_1 and B_2 are stuck to D in the same way. The distance $B_1 B_2$ is 20 mm. The crystal plate is placed between the two pairs of axes. C and D are pressed together by the two screws E. In order to cause an evenly distributed pressure the screws act against spring-piece F upon which two small tilts press against the middle of D. An opening, 6 mm high and 35 mm wide is cut out of both C and D, through which the X-radiation can hit the crystal. The front piece C is fixed to bottom plate G.

The first specimen of this holder has been used during eight months. A quartz plate, cut parallel to atomic plane $1\bar{3}40$ was adjusted optically to a radius of 450 mm. The width of the Cu $K\alpha_1$-line at half maximum intensity was then measured with a Geiger counter. The value obtained was 0.65 X.U. As the crystal opening was 8 mm, the width of the slit of the Geiger counter 15 μ, and the natural line width 0.58 X.U., the result corresponds very well to the natural width increased with the Johann broadening.

Holders of this design have been used with good results also in Cauchois-spectrographs.

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